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Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "Joint state-parameter estimation of a nonlinear stochastic energy balance model from sparse noisy data" *by* F. Lu et al.

Anonymous Referee #2

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General comments

This paper discusses how to estimate parameters for spatial-temporal models. It considers testing the methodologies on a nonlinear stochastic energy balance model (SEBM) in paleoclimate reconstruction problems. To resolve the ill-posed Fisher information, it considers using a strongly regularized approach. Systematic numerical tests were run using the particle Gibbs ancestral sampler (PGAS).

Overall, I think this paper is well written, and it provides detailed discussions on the related methodologies. There are a few minor issues listed below. I recommend its

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Discussion paper

publication after these issues are addressed.

Specific comments

Paleoclimate reconstruction seems to be an interesting and nonstandard question. So it might be worthy to give some details on how the SEBM is formulated, for example, what do each parameter θ stands for. It is also better to give some references on why the specific parameters are chosen. For example, it seems that data are available with time-interval $\Delta = 0.01$ (what is the time unit here?). But is this practically true?

While I agree the Fisher information matrix may be ill-conditioned, but I don't see immediately why the strong regularization approach is the right or natural way to fix it. The numerical results show that the regularized posterior has obvious biases, and sometimes close to being the prior. The strong regularization used here might be the cause of this. An alternative approach might be using the following version instead of (21)

$$p^N(\theta|u,y) \propto p(\theta)^\alpha [p_\theta(u)]^{1/N}$$

where α is a parameter in $[0,1]$, and it can be tuned for a better posterior.

Technical corrections

1. Page 9, Fisher information matrix: since most NPG readers are likely to be geoscientists, maybe you should explain that in statistics, Fisher information dictates the asymptotic inference difficulty and give references. Also, there should be some explanations on why this matrix is ill-conditioned, not just some simulation plots.

2. Figure 2. The figure caption below "Data size $\log_{10} N$" is garbled. This happens to many figures later on as well. This might be a problem with my own computer/printer. But you better check.

3. Page 11, what is u_i? And it is better to define u_c and σ_o with mathematical terms.

4. Page 13, I think Markov chain might be too abstract a term for NPG. I think you can replace it with MCMC for the same meaning.

5. Page 18, line 2, there shouldn't be parenthesis for θ_0, θ_1.

6. Page 29, line 7, "see e.g. [". You miss some content here.

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